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ABSTRACT

Computerized career guidance systems hold the promise of providing a breadth and depth of information for which counselors are not suited. At the Institute for Mathematical Studies in the Social Sciences, Stanford University, an individualized counseling system (ICS) is being developed which integrates advanced techniques from comptuer assisted instruction and computer science intc an interactive computer system for vocational guidance counseling. The ICS system seeks to individualize and modularize the guidance process by providing (1) better computer models of individual students, (2) flexible data structures to permit ready and nearly automatic updating of data bases for guidance, and (3) increased transferability of programs. It is estimated that, even in the trial phase, ICS will be as cost effective as systems already in production use. (CHV)

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ICS: AN INTELLIGENT VOCATIONAL GUIDANCE COUNSELING SYSTEM

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ICS: An Intelligent Vocational Guidance Counseling System

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Introduction and Focus

Computerized Vocational Guidance systems hold the promise of providing a breath and depth of information for which counselors are not suited. The main reason for this is that significant portions of vocational guidance are ideally suited for a very fast, accurate clerk. Tremendous amounts of information must be kept close at hand and transmitted to the inquiring student when needed. Further, through the developments in computer-assisted instruction and artificial intelligence, the computer can build a model of the student accurately and retain it indefinitely, permitting each session to build on the last.

These potential benefits have not yet been fully realized for several reasons. But at the Institute for Mathematical Studies in the Social Sciences (IMSSS), Stanford University, we are developing an individualized counseling system (ICS) to meet the promise of computerized guidance systems.[2] The system integrates advanced techniques from computer-assisted instruction and computer science into an interactive computer system for vocational guidance counseling. The design of ICS incorporates innovations and improvements in computer models of student interest and ability, program control, and structure of dynamic data bases.

Objective of ICS

We have surveyed many implemented computer systems for vocational guidance and counseling. The main deficiency of these systems is that they do not use the symbol processing capabilities of the computer to optimize the individualization of the guidance process. A second problem is that some of the best systems fail to be transportable due to hardware and software constraints, and thus limit their national impact.

The ICS system seeks to individualize and modularize the guidance process by providing: (1) better computer models of individual students, (2) conceptual treatment of dynamic data bases for guidance, and (3) increased transportability of implemented systems. Each of these points is discussed below.

Computer Model of the Student

The guidance systems we have surveyed all stress the importance of individualizing the guidance process and offer the prospect that computer-assisted guidance could do this. For example, Katz et. al. (1972) speak strongly for individual freedom and control in the SIGI system. Tiedeman (1970) deals with this problem in the ISVD system. A difficulty in some current programs is the roteness of the student's interaction with the computer. "The appearance of determinism" is addressed by Super (1970) where "the flow 'if a then b, if b then c' makes the outcome seem inevitable." An objective of ICS is to go beyond these initial efforts by using optimization and individualization techniques from computer-assisted instruction.

Dynamic Data Bases

The issue of current and accurate data bases is obviously of prime concern for computer-based systems for vocational guidance. As Krol! notes "their effectiveness is dependent upon dynamic, ever-changing data files. It [the computer] is powerless to create data that heretofore have not been assembled or compiled in different forms." Of course the computer cannot create data from thin air. But data representation need not be limited to variations of lookup tables. More useful and sophisticated representations of data, including more powerful methods of making inferences from data, do exist and are being investigated in the ICS project.

Transportability

"Computer-based guidance systems will probably never become a reality in education until the same program can be used in many locations," according to Kroll (1973). Within the hardware and software constraints discussed in later sections, the ICS project seeks to maintain transportability.

Expected Benefits

The main benefit to be realized from the ICS project is a demonstration of how sophisticated computer models of data representation can be used to individualize the vocational guidance process in the context of computer-assisted guidance. The benefit for the individual student will be an increase in flexibility and pertinence of the dialogue with the computer.

Harris (1972, p. 9) points out that "the present types of computer-based guidance systems are in a very early stage of development," and that computer "technology is already well ahead of innovative guidance thinking." We agree with this statement. However, she goes on to say that "the refinement and expansion of the involvement of computers in guidance will depend more upon the innovativeness and dedication of practicing counselors than upon systems specialists. We find ourselves in some disagreement with this remark.

We feel that what is needed is the dedication and innovativeness of computer specialists who can comprehend the needs of the practicing guidance counselor and translate those needs into an improved and articulated guidance application. At IMSSS, we are capitalizing on a great deal of experience working with dedicated professionals in educational specialties, such as handicapped and minority instruction. It is our experience that we have something to offer these specialists, but that to be effective there must be a genuine dialogue. So we have regular contact with practicing guidance counselors which helps us to maintain a firm sense of what is actually needed and what will be most useful.

ICS seeks to improve the degree of individuality that the computer-assisted guidance system offers the student by improving both the model that the program has of the student and the model of the substantive guidance data base. In this effort, we are using computer techniques that have proved successful in individualizing computer-assisted instruction (CAI).

A related goal of ICS is to provide student-directed dialogue, and through this dialogue to increase student control over the counseling process. In discussing directions for future guidance systems, Harris (1972, p. 10) mentions the need for programs "which allow the counselee to prepare his own instructions to the computer and thus alter the predesigned processes." These two things are closely related, since the ability of the program to "alter the predesigned processes" in a useful way depends on the representation of the student's interests.

Consider the following scenario from the CVIS system (Harris, 1972):

Computer: Hi, Bill Brown. That is your name, isn't it?

Student: Yes.

Computer: The last time you were here, you were exploring occupations in the category of science that require community college training. What would you like to do today? Your wish is my command.

1. Continue exploration of this list of occupations.
2. Make new decisions about training.
3. Make new decisions about field of interest.

Student: Three.

Computer: Please choose one of the following. (Displays list of eight categories of interest.)

Student: Technology.

Computer: You showed significant interest in this field on the last interest inventory you took.

This dialogue reflects the linear nature of the program. A simple branching mechanism controls the student-computer exchange, and the student has no opportunity to pop-out to a higher level, establish his own flow, or ask questions according to his interest and needs. Likewise, the model of the student for this dialogue could be quite simple—a few variables to count interest in various occupational and educational features of a data base which is in reality more complex and interrelated than the program allows.

The restrictive design of the encounter is reminiscent of programmed instruction texts in the past. In fact, some guidance systems need not be implemented on the computer at all. Since they can be written out as text scripts in a manner similar to programmed instruction. We are not questioning the subject-matter expertise in the CVIS system. What we are arguing for is the application of the same technology to vocational guidance systems which transformed the notion of programmed instruction into the sophisticated and flexible computer-assisted instruction systems now in existence.

The Components of ICS

The major components of ICS are a network model of the student, a network model of the guidance data base, and a MATCH component which relates the two models in a useful way. These components are shown in Figure 1, page 84.

Network Model of the Student

Instead of modeling the student's interests and occupational goals in a relatively simple data structure, we are constructing networks that represent those interests. These networks contain nodes relating to occupations, fields, kinds of work—all interconnected in a manner that shows the conceptual relation these things have to the student. This Student Interest Network (SINE) may be seen in Figure 1. A general discussion of the use of networks in the computer representation of human knowledge and belief can be found in Simmons (1973), Schank (1973), and Abelson (1973).

Network Representation of the Guidance Data Base

The ICS system also contains a network with a simplified model of the complete guidance data base incorporated in the program. The original guidance data base, as we have stressed, is obtained from currently existing systems. The Guidance Data Network (GDN) can be thought of as a guide to the data base, simpler than the complete data base, but more complex than an index or table of contents would be. The purpose of the GDN is to model the complete guidance data base for comparison to the network that represents the student. This comparison is performed by the network matching component MATCH. For a discussion of the uses of pattern matching in computer representation of knowledge see Wilks (1973).

Networks have been used to optimize CAI instruction, and this successful use is part of the reason we are applying networks to ICS. For example, the Basic Instructional Program (BIP) at IMSSS (Barr, Beard, and Atkinson 1975) uses a model of the student's acquisition of programming skills and concepts to select exercises for the student. In BIP, the exercises of the curriculum are also connected in a network. By comparing the model of the student with features of the stored curriculum network the exercises are selected.

Comparison of Student and Guidance Networks

The MATCH component compares the SINE (Student Interest Network) and the GDN (Guidance Data Network) and provides the basis for selecting the questions and responses that ICS presents to the student. The uses of this comparison include:

1. Optimizing the questions asked by ICS, so that the greatest amount of information is obtained in the smallest number of questions. This corresponds strongly to the use of optimization techniques in the reading project at Stanford (Atkinson, Fletcher, Lindsay, Campbell, and Barr 1973), where items from the reading curriculum are selected to reduce the number of items the student must see in order to attain a given ability in the various categories ("strands") of the curriculum.

2. Presenting the student with information most closely related to the areas of his interest and skills.

3. Providing the student with information, within general areas of interest, which strengthens his conceptions about the occupations involved. For example, suppose a student shows interest in medical careers, as evidenced by his saying that he wants to become a doctor, but his network indicates an incomplete understanding of the structure of the medical careers available. It may then be appropriate to provide more information, not only by presenting specific facts, but also by giving the student a firmer sense of the structure of the medical fields, educational requirements, and so on.

Most current computer-assisted guidance systems use a simple table lookup and search strategy. We stress that alternatives to tables as representations of knowledge and to simple search strategies must be employed for truly individualized guidance. Recent work in the field of artificial intelligence has suggested that computer programs can interact carefully with humans only if they have detailed semantic models of the interaction process (Winograd, 1971).

The Dynamic Data Base

One of the problems typically mentioned about computer-assisted guidance systems is the difficulty in changing and updating the data base. This is seen as a yearly task of installing new tables and updating the program where necessary (Kroll 1973; Harris 1972). The past several years have seen enormous structural changes in economic patterns and job opportunities, as well as the value systems of students. (See Katz [1973] for a discussion of the role that values play in counseling in the SIGI system.) Such changes may not be representable in the mere updating of parameters and tables. ICS is designed with flexible data structures to permit ready, and nearly automatic, updating by means of interactive data management routines, which are an integral part of the program.

Transportability

We recognize the desirability that the research and implementation involved in ICS be as transferable as possible to other educational settings and systems. One associated problem already mentioned is that the data base may contain geographically local information and requires periodic updating.

The issue of the transferability of guidance programs is considered in detail by Kroll (1973), who points out that the large diversity of hardware and software often precludes implementation on a given system of a program written elsewhere. This problem is not specific to vocational guidance systems, or even more generally to the uses of computers in education, and hence is not really "solvable" by a project of the scope of ICS. There are too many broader and more complex issues at stake, including hardware and software compatibility, telecommunications and networks, and the issue of large centrally located computers versus small, on-site minicomputers. While we cannot provide a definitive solution to the problem, we recognize its importance. Our objective is to anticipate the form of likely solutions and we are trying to provide the most reasonable implementation under the current uncertainties.

Software Compatibility

Guidance systems written in machine language clearly have the most limited transferability because they depend on the specific machines for which they were designed. Currently, OIAS (Kroll, 1973) is written in IBM 360 machine language, and SIGI (Godwin, 1974) is written in machine language for a dedicated PDP-11.

Languages such as BASIC and FORTRAN are widely implemented on a variety of large and small machines. Currently, the Guidance Information System, marketed by Time Share Corporation, is written in both FORTRAN IV and BASIC. It runs on some medium size (PDP-11) and large machines (PDP-10), provided the proper disk system is available. However, these languages are primarily intended for numerical rather than symbolic processing, and have poor control structures since they generally lack recursion.

We have chosen to implement ICS in LISP (McCarthy, 1969). We are using a neutral dialect of LISP that will be transportable with little difficulty to many larger machines, such as IBM 360-370 and CDC 6600, as well as some smaller machines. More importantly, however, the choice of LISP is the best language for implementing ICS, given the constraints currently facing such projects.

1. The computational complexity of the ICS system currently requires a relatively large machine (the size of a PDP-11 or larger) regardless of which high-level language is chosen. So an implementation in FORTRAN or BASIC would not dramatically increase the immediate transferability of ICS to smaller machines, unless it was machine coded.

2. LISP is the language most frequently chosen when data structures become complex and difficult to predict in advance. As a language it is relatively stable and widely used.

3. The prospects for later transfer of ICS and the ideas that will be incorporated into it are excellent. This is because, whatever solutions are found to the general problems of hardware-software compatibility, algorithms designed in LISP will have a great influence on the areas for which they are designed. If ICS succeeds in its goals, the work will be transportable.

Hardware

No special hardware is required to run ICS. The mainframe machine must be capable of supporting LISP or an equivalent system, and a high-speed disk for the data must be available interactively.

The peripheral constraints are minimal. ICS is designed to run on any full-duplex ASCII terminal, hard copy or CRT, with appropriate code for both contingencies. We will be using CRT displays running at 1200 baud for high-speed delivery. These terminals are standard devices that currently market for about $2,200 each. We have chosen this method of information delivery for a comprehensive system over other media (e.g., slides, films, etc.) because of the basic reliability and serviceability of these display units as demonstrated at the IMSSS computer laboratory and in IMSSS field projects.

Cost Effectiveness

The Institute has always stressed the need for cost-effectiveness when using computers in education (Jamison et. al., 1971), and IMSSS has instituted many internal measures to optimize the use of its facilities. As a result, even in the trial phase of the project, the system will be nearly as cost effective as systems already in production use. For example, the terminal cost for a month during the second period will be less than $1,000, including the cost of a phone line.[3] Estimating the effective use of a terminal to be six hours per school day, this amounts to approximately nine dollars per student contact hour. As a comparison to a commercially available system, the Time Share Corporation GIS system is said by Kroll (1973) to cost six to twenty dollars per hour, using Model 33 Teletype terminals at 110 baud for the delivery. We estimate that we could provide delivery on a production basis for less than the lowest amount quoted for the TYMSHARE system, i.e., six dollars per contract hour.

Conclusions

Our growing experience with ICS is producing a system for guidance which is meeting the promise of computerized guidance systems. We are developing a data base management system which is handling the task. Nearly automatic updating of information is a reality in many important respects. Finally, the student modeling effort is producing a more responsive counseling engagement with the student.

At a time when the orientation of college students is toward the world of work and the world of work is changing rapidly, the realization of the promise of computerized guidance systems is even more necessary. This report is of a project which fits this need and which is proving successful in meeting the promise of computerized guidance systems.

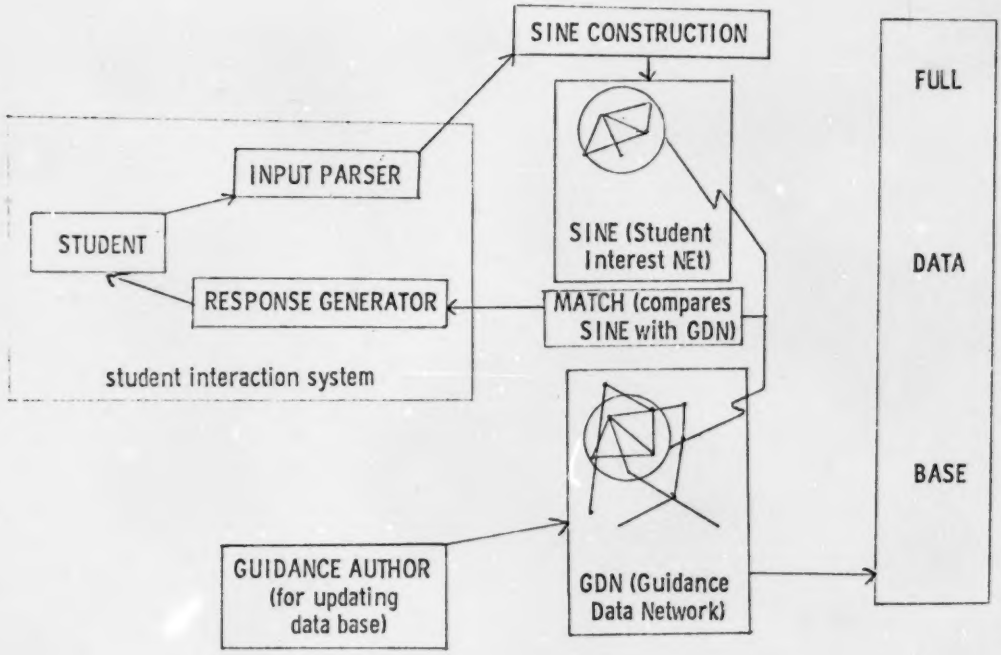

Figure 1. CIS System Components

Notes

1. Correspondence with regard to the contents of this paper should be directed to Professor Hinckley.

2. The authors would like to thank Professor Patrick Suppes for his able direction of this project. The work described here is being supported under Department of Health, Education, and Welfare Office of Education grant G007603721.

3. By using Model 33 teletpyes, we estimate that we could reduce the cost to about fifty dollars.

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